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No. 36

THE PROBLEM OF FERTILIZERS  
IN RICE GROWING  
IN SOUTH VIETNAM

by  
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## INTRODUCTION

Among the methods suitable to increasing agricultural production figure principally the amelioration of the vegetal material and the upkeep of the fertility of the soil; these perfections often are realized by a simultaneous way and one today associates very frequently the problem of fertilizers to that of the research of varieties having the power to best utilize them. In a country the progress of agriculture can, in a certain measure, measure itself by the consumption of fertilizers; their use marks an evolution of the traditional culture towards a rationalization of the production methods, which tends to transform agriculture into an industry.

The problem of fertilizers is examined here in relationship with rice-growing and in the geographical framework of South Vietnam. This study is ripening; from all parts the great rice-growing countries of the world are solicited to produce more to guard against alimentary shortage which several overpopulated Asiatic countries suffer from. Vietnam must answer, for its part, to this international effort and this explains the attention that they are actually bringing to the use of fertilizers in the rice fields.

But it is opportune that a technician should make the point of this question, put in relief the experience acquired by the trials and observations followed from more than 20 years in the country of Indo China. This is the essential goal of this memoir; it furnishes, by its well supported documentation, an excellent base for the experiments to follow. Right now certain rules of use are well known and must not be transgressed under penalty of failure; they are here recalled with lucidity.

Know that the author has also treated and exposed frankly the delicate question of the revenue of the fertilizer. One must not fear to say that quite often, in actual economic circumstances, the use of fertilizers is not paying, or else not enough to interest the rice grower; on the other hand, it requires an expenditure that frequently passes the possibilities of the exploiter. The generalization of the using of fertilizers thus

requires governmental measures, either to favorize short term credit, or to force the practice of fertilizing, even if the benefit of particular farmers remains low. Whatever be the interest withdrawn from the operation by the rice growers, the country must, by this means, increase its exportable surplus crop; at the same time that it carries out this humanitarian endeavor, it bases its economy on a produce of first necessity.

The use of fertilizers in rice-growing thus appeared here at once as a technical problem, by its nature, and a political problem in its application.

P. the Director of the Indochinese Rice-Office

L. ROGER.

**The problem of fertilizers  
in rice-growing  
in South Vietnam**

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If one compares the average yield of the rice fields of South Vietnam to those obtained in the neighboring countries situated in the same latitude, that is to say almost in the same climatic conditions (pluviometer, luminosity), one declares that they are not sufficiently productive. Thus if the yields per hectare of Siamese lands, Malaysian and Indian lands are respectively from 1,800, 1,480, 1,400 kg., that of the rice fields of South Vietnam is only from 1,200 to 1,300 kg. This small yield (1) is due to numerous factors whose principals are: a defective hydraulic system, an insufficient use of organic and mineral fertilizers). It is a nearly extensive culture that does not demand the contribution of important capitals and which despite everything relates sufficiently thanks to the natural richness of the soil. It is however possible to augment our rice-growing production in ameliorating the milieu of culture by a more satisfying hydraulic system and by adopting a more intensive method by employing fertilizers and varieties of high yields.

The realization of this vast program would permit the yield of the traditional culture to rise to the level of that which one obtains with selected varieties in the experimental stations where the culture is made under good irrigation and fertilizer conditions. It would double our rice-growing production.

The amelioration of the culture milieu by the installation of satisfying hydraulic equipment is the most efficacious method of ameliorating production (2), however its realization demands time and the contribution of important capital.

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(1) It is necessary to point out that in the average yield statistic given for Vietnam, one takes into account the yield obtained in lands sometimes very disinherited, while abroad, the rice culture is installed uniquely in the regions most favorable to this culture.

We will confine ourselves in this study to the fertilizer problem. If, because of the vast stretch of insufficiently managed land, the jobs of hydraulic management still remain of first importance to South Vietnam in the augmentation of the rice-growing production, the use of fertilizers could however ameliorate the yield, on lands managed as well as on those that are not, and would permit an increasing yield going from 25 % to 50 %, as one often declared in the diverse essays undertaken at the Indochinese Rice Office. It would above all have the advantage of being realized at any time.

The use of mineral fertilizers is almost ignored in the traditional culture of South Vietnam. In order to recommend usage, it is necessary to put at the disposition of the peasant good fertilizer formulas. However, despite the relative uniformity of the nature of the soil, the South-Vietnamese rice fields must be redistributed in different rice-growing zones, to which the different fertilizer formulas correspond.

The rational utilization of fertilizers thus requires a preliminary study of the agrological and hydraulic conditions of the soil, and meteorological factors. This data permits one to trace a map of the different rice-growing zones, needs in fertilizing elements for the diverse zones and to recommend fertilizer formulas proper to each region, or if possible to each province. This study thus comprises the following principal points:

- A. \_\_ Study of the different rice-growing zones of South Vietnam.
- B. \_\_ Fertilizer formula for the different rice-growing zones.
- C. \_\_ Actual situation of the use of fertilizers.
- D. \_\_ Intensification of the use of fertilizers.

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(2) The Vietnamese rice-grower realizes the importance of the hydraulic factor. According to him, the factors conditioning the yield are cited in the following order: "in the first place water, in the second fertilizer, in the third the cultural works, in the fourth the seeds" (Nhat nuoc, nhi phan, tam can, tu giong).



## A — Study of the different rice-growing zones

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As it was earlier said, the distribution of rice fields in different zones is based on climatic data, hydraulic and agrological data.

### I. — Climatic conditions

The temperature being quite regular in the course of the year in South-Vietnam, it is, from the climatic point of view, the pluviometer that commands rice-growing.

The climate is that of tropical regions and comprises the succession in the year of a dry season and a rainy season. Beside a somewhat weak luminosity, because of the great number of cloudy days and the relatively short duration of the day in relationship to that of temperate regions (1), the temperature and pluviometer factors of South Vietnam are clearly favorable to rice. The annual rain falls vary from 1 m 50 to 2 m, that is to say 2 to 3 times superior to those registered in the rice-growing regions of France. (Camargue). Beside this substantial water contribution, the rains contribute enormously to the contribution of fertilizing elements. The rain water doses made in Thailand demonstrated that a total of 12 kilograms of nitrogen per hectare is deposited annually by the rains, about three-fourths of this volume are constituted by ammonia and the rest by nitrate (G. Bertrand also found traces of K<sub>2</sub>O and MgO in the water).

The rainy season lasts almost 7 months, from May to November. The rice-growing campaign begins, for healthy lands, from the beginning of the humid season; for toxic lands, it is somewhat retarded so that the soil can be washed by the first rains.

The rains are not regular during the 7 months; the humid season is cut by a short period of dryness, more or less acute, that takes place

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(1) The luminosity exerts a great influence on the yield. If in Italy, the yield is nearly the quadruple of what one harvests in our country, it is largely due to the luminosity. The number of sunny hours during the 4 first months of rice vegetation is 1209 at Vercelli, while it is only about 700 hours here.

generally towards the month of August. This risk often hinders the vegetation of the rice and retards, in the double transplanting zone, the cultural operations (2nd transplanting), or occasions an inadequate supply of water at the time when the rice has most need of it (newly transplanted rice plants).

The end of the rainy season habitually takes place at the time of maturity of the plants and at the time of harvest, the earth is in general quite dry or muddy. The premature varieties put aside, the rice is harvested in favorable meteorological conditions, the beating down and the winnowing can be, from this fact, executed in the field. The cleansing of the grains in particular is greatly facilitated by the presence of the North wind.

## II. Hydraulic conditions

The principal sources of water in South Vietnam are:

— the Mekong, that comprises two principal arteries: the so-called Mekong and the Bassac;

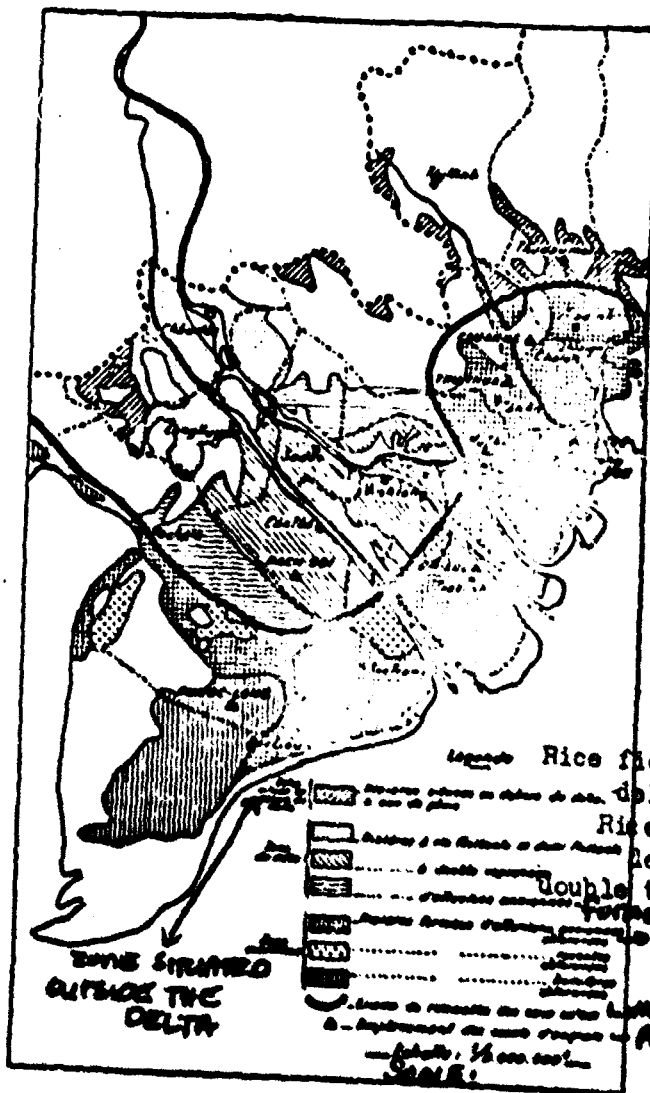
— the Vaio with its two arteries: the Oriental Vaio and the Occidental Vaio;

— the song Donnai.

The Mekong, by its flow and the stretch of areas that it waters is the most important. Beginning from Vinh-Long, it divides itself into 4 arms (Song Co-Chien, S. Ham-Luong, S. Ba-Lai and S. My-Tho). The Mekong mixes its alluviums with those of the Vaio and the Donnai and the ensemble forms a vast delta cut by multiple arms where the salty waters flow.

The annual floods of the Mekong do not have the terrible effects registered in North Vietnam by the Red River, in case of ruptures of the dikes; its bed not being dammed the inundation can spread itself over a great area 20,000 km<sup>2</sup> and it is rarely abrupt and violent. The elevation of the water, at the time of the floods, diminishes gradually as one approaches the sea. Being from 3 to 4 m at Chaudoc, it lowers itself to 1 — 2 m at Longnuyen — Sadec and to 0 m50 — 1m at Cantho — Soctrang; below the course of water the inundation spreads itself over a larger region and the proximity of the sea permits a more rapid evacuation of the water thanks to the action of the tides.

The choice of the varieties like the practice of cultural operations is made in function of these phenomenal floods. Thus in the zone where the water bed is deep, the floating rice is employed; in the Longnuyen zone — Sadec, it is semi-floating rice; and in the Cantho zone — Vinhlong — Soctrang, it is rice that requires double transplanting.



Rice fields situated outside the delta, with rain water  
 Rice fields with floating and dead-floating rices  
 Double transplanting  
 Former alluviums  
 Rice fields of former alluviums  
 Limit of the rise of salt waters  
 Places of fertilizer trials

The floods still exercise a beneficial action on the lands that they cover, above all the Bassac waters, of neutral reaction (pH 6, 9, average of 51 analyses of water drawn out at different dates and points) and a good silt content: 238 g 9 to m<sup>3</sup> (1).

Apart from the phenomenon of the floods, the liming also plays an important role in South Vietnamese rice-growing. The lands situated far from the sea and possessing an inferior side to that of the level of the high tides benefits from a bi-daily irrigation with easy running water. The lands possessing a more elevated side are only irrigated at the great tides, but remain however humid all year round. These two types of rice fields belong to the category of rice fields flooded with easy running water; one there includes also rice fields receiving water from the rivers at the time of the floods.

Another category of rice fields is that of lands covered with briny water during a more or less great part of the year. One distinguishes, actually, rice fields with low dimensions, inundated with salty water by the rise and fall of the tides, and those having more elevated dimensions subjected only to the rising of the salts by capillarity. This category of lands demands a particular preparation (desalting of the soil), the use of special varieties, resistant to salty water, like the Cadung Gcong and the Tauhuong.

In addition to these two categories of rice fields, one must cite the rice fields with rain water. These are the high lands, situated far from the course of the water. They have a very uncertain yield, due to a sufficient pluviometer but often poorly distributed. The harvest by this fact can be compromised if the short dry spell is too accentuated.

### III. Agrolological conditions

The dense network of water courses gives to South Vietnam, from the agrolological point of view, a certain unity; these are in general lands of more or less recent alluvial formation.

Despite this uniformity, one can distinguish for South Vietnam:

- 1) a zone situated outside of the delta;
- 2) the so-called delta;
- 3) the maritime zone.

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(1) The waters of the Nile, of the Mississippi, of the Gange have far higher silt content; 1 kg 500 for the Nile, 1 kg 750 for the Mississippi, 1 kg 950 for the Gange.

The first comprises rice fields of the provinces of Thudaumot, Bienhoa, Tay Ninh and a part of Chaudoc (Occidental segment). They are of detrital and alluvial origin, quite good, poor however in nitrogen, but in general sufficiently furnished in  $P_2O_5$  and quite rich in  $K_2O$  (1). These are the rain water rice fields, of generally weak and very uncertain yield, because of the total subjection of the culture to atmospheric conditions. The area of these rice fields in this zone is relatively restrained and the major part of rice consumed in these provinces come from the more productive lands of the West.

2 — the so-called delta: By following the Mekong upstream and downstream, one can there distinguish several different rice-growing milieus:

a) The floating rice zone englobes nearly all of the province of Chaudoc and a part of Longxuyen. These are rice fields formed by recent alluviums that are non-humic, poor in  $P_2O_5$  except for a large band situated along the Mekong for Chaudoc and along the Bassac for Longxuyen. The content in  $K_2O$  is equally poor, beside the rice fields situated in the SW of Longxuyen and neighbors of Rachgia. From the point of view of the physical nature of the soil, it is a question of silt-siliceous; the predominance of large constituents is due to the fact that the zone considered is situated at the beginning of the dejection cone of the Mekong. The height of the water during flood times imposes the use in this zone of particular varieties, floating rice. The culture remains very risky, and in general, one discounts a good harvest out of three. Thus the production in the province of Chaudoc oscillates between 30,000 and 200,000 tons, following the direction of the flood (for an area of 150,000 hectares of rice fields).

Comparable elements in 0/00 of naturally dried land:

	$P_2O_5$	$K_2O$	N
very poor soils....	0.10	0.10	0.25
poor — .....	0.10 ± 0.20	0.10 ± 0.20	0.75 ± 1.25
average — .....	0.30 — 0.30	0.20 — 0.30	1.25 — 1.75
rich — .....	0.30 — 0.40	0.30 — 0.45	1.75 — 2.25
very rich —...	0.40	0.45	2.25

The cultural works, labors and seeds, are begun early in this zone, in April — May, before the rains, to permit the plants to have sufficient vigor at the time of the floods. The principle risk is insufficient water at seeding time; the years when the rains are insufficient at the beginning of the period, the rice grower sees himself obliged to plant relief seed beds.

(1) The estimation of the soils, from a richness in fertilizing elements point of view is based on the fertility scale adopted by the Indochinese Rice Office.

The use of fertilizers is totally ignored in this zone and the success of the cultures depends on the meteorological and hydraulic conditions; the yield is above all conditioned by the course of the floods, which begin in general towards the beginning of July.

One can connect with this type of rice fields, the zone of semi-floating rice and decreased rice, which is found more downstream of the Mekong. It comprises a good part of the provinces of Longxuyen and Sadec. As with floating rice, semi-floating rice is cultivated by direct seed bed, on a terrain that is worked and harrowed. While floating rices support heights of water from 3 to 4 m, demi-floating rices resist only a small height of flood water; certain ones among them present the same characteristics as the floating rices (knotted roots, special tissues...); others on the contrary resemble the ordinary varieties, from which they differ however by their rapid growth or the production of a longer straw. The diminished rice is a transplanted rice; this culture method is practiced at the borders of the water lines, the depressions remaining inundated for long periods of time, or in the river islands.

b) The zone of double transplanting rice comprises the provinces of Vinhlong, Cantho and a part of Soctreng. These are lands rich in organic materials, abundantly provided with  $K_2O$ , however poor in  $P_2O_5$ . On these lands, working the soil is very brief; the labor, necessary elsewhere, is replaced in these lands approaching peat mosses, by a mowing of the grasses followed by a rolling.

Although the use of fertilizers there may be ignored, this zone furnishes however the best yields of South Vietnam.

3 — Maritime zone: the maritime zone (limited by the thick line drawn on the map) is subjected to the rising of the salt water, be it by the action of the tides, or by capillarity in the dry season.

It comprises:

a) — The old lands of the provinces of Cholon, Tanan, Gocong, and a part of Mytho and Bentre. A good part among them yield 2 crops. These are the relatively healthy rice fields, however poor in N, in  $P_2O_5$  and rich in  $K_2O$ .

b) — The new lands of Travinh, Soctrang, Bac Lieu, Bachgia and a part of Bentre, rich in humus, sufficiently provided in  $P_2O_5$  and  $K_2O$ , however very toxic by the invasion of salt water and by the strong content in alumina of the lands.

The old rice fields are almost the only ones in South Vietnam that receive a mineral manure, because of the wearing out of the lands exploited too intensively and for too long a time.

The new lands, richer, bear however very risky cultures because of a poor hydraulic system. The management of this zone, comprising essentially the digging of the Quan-Lo canal — Phung-Hiep, unfortunately provoked the access of salt water inland, without however notably ameliorating the drainage of surplus waters. These lands, excessively toxic, cannot be cultivated until an energetic washing of the soil by the rains occurs. The working of the soil which necessitates the labors and harrowings is often hindered by the lack of beasts, rearing is in effect rendered sometimes difficult, by the lack of easy running water, when the dry season is too acute.

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\*   \*

The characteristic, very striking, of the nature of the soil of South-Vietnam is the toxicity of its lands. This toxicity is all the more greater because the land is more alumed: the old rice fields, better washed, having a satisfactory hydraulic system or an adapted management, are less toxic than the new lands of the West. The alumed lands bear a particular vegetation, a small reed under the name of "Co Nang Kim" (Helecocharis equisetina) whose aspect and dimensions vary with the degree of toxicity of the soil: reddish yellow, it passes from yellow and light green, to become a beautiful deep green and attains the level of one's belt, when it grows on faintly alumed lands. In the dry season it is frequent to observe on the surface of these alumed soils, white effervescences due to the salts that these lands contain and which, under the influence of capillarity phenomena, raise to the surface.

Another particularity very well known of these lands is their flocculating power; if one there introduces cloudy waters charged with silt, they come out of it completely stripped and perfectly clear. Finally, if they are submitted to a salted liming, they take on a friable structure and without cohesion, rendering difficult the construction of impermeable dikes.

The origin of the alumed lands results from an ensemble of phenomena which are quite complex. The essential factor is the very pushed decomposition of sedimentary rocks or silicated eruptive rocks, notably containing silicates of alumina; this provokes the migration of siliceous elements under the form of pseudosolution and the presence in the soil of free alumina and of colloidal complexes capable of liberating from it. This liberation is particularly accentuated by the strong acidity of the soil.

The alumina content of these soils is very high as the figures here below show concerning a cultivated land situated on the circumference of the Jones Plain (1).

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(1) Extract from the Study of lands and alumed waters by R. F. AURIOL and IAN-VAN-VANG Publication of the Indochinese Rice Office no. 52.

Content in "Al" of the solutions of soils from Cau-an-ha

Samples taken before the rainy season  
Results expressed per thousand of of fine earth dried at 100°

Samples	Soil Sub-soil	
	Al g/100	
Désignation des échantillons	Soil	Sub-soil
1	1.838	0.813
2	1.803	0.843
3	1.992	0.973
4	1.621	0.736

The changes provoked by alumina (2) are manifested by an accident known under the name of "tiem phen"; its symptoms recall somewhat those of certain sclerote maladies. The yield is very reduced above all because of the great proportion of empty grains.

The mechanism of this intoxication can be thus explained:

The plant mobilizes its reserves in  $P^{25}$  and directs them towards the absorbent hairs, zone of penetration of the toxic Al ions. These are then precipitated by the  $P^{25}$ , this reaction taking place on the spot in the cortical cells of the absorbent hairs. There results from it:

a) a deficiency of  $P^{25}$  in the plant itself;

b) a particularly stable clogging of the cortical cells by a precipitate of insoluble iron and alumina phosphate. This clogging constitutes an impermeable screen, stopping all possibility of osmotic changes with the soil solutions, exchanges N-P-K vital for the development of the plant. In particular, the plant can no longer take  $P^{25}$  from the soil that is necessary to it, would this be only to reconstitute its reserves in this element, reserves that it has just exhausted to defend itself against the toxic Al ions (VALYE)".

The toxicity due to alum in these lands, as that of the marine salt of the Maritime zone, can be attenuated if the rice grower provides himself with a satisfactory hydraulic system. The rice requires much water for its development, and the earth has need of much water to eliminate the toxic elements that are found in it.

It is this dilution that renders possible the culture of a good part of the rice fields: the following table (3) shows the importance of this

(2) The toxicity of alumina manifests itself with a dose of 50 mg of Al per liter be it less than 0g 618 of alumina sulfate per liter of soil solution (of a kg of earth).

(3) Taken from a study of earths and alumed soils by AURIOL and VANG already cited.



action. One sees there the differences drawn up in the analyses of 2 series A and B, of 4 samples of soils and sub-soils — taken at Cau-an-ha, exactly in the same places, but at different epochs; the borings of serie A being made in April 1933, before the rains, those of serie B at the beginning of August, during the rainy season of the same year.

**ACTION OF THE WASHING OF THE SOIL ON THE ALUMED LANDS OF CAU-AN-HA**

(Results expressed per thousand of land dried at 100°)

Désignation des séries	Sites							
	Emplacement N° 1		Emplacement N° 2		Emplacement N° 3		Emplacement N° 4	
	S	S/S	S	S/S	S	S/S	S	S/S
SULFATES								
Série A.	6,792	1,381	6,295	1,968	7,340	4,998	6,147	2,942
— B.	2,621	1,327	1,955	2,984	3,567	3,155	2,160	1,887
ALUMINE (AL <sub>2</sub> O <sub>3</sub> )								
— A.	1,076	1,337	1,409	1,595	1,767	1,840	1,015	1,395
— B.	0,853	0,801	0,375	0,856	1,077	0,633	0,449	0,788
SOUDE (Na <sub>2</sub> O)								
— A.	1,637	1,626	1,241	1,915	1,616	2,172	2,924	1,968
— B.	1,359	1,335	0,989	1,462	1,010	1,204	0,774	0,868
PROTOXYDE DE FER								
— A.	0,154	0,138	0,175	0,164	0,156	0,125	0,155	0,151
— B.	0,043	0,145	0,043	0,046	0,029	0,043	0,125	0,072

South Vietnam possesses a dense network by still has insufficient canals (1). The principle frame of the hydraulic program can be considered as sufficiently installed in the old provinces; but it is absent in the newly installed rice fields zone. It is inexistant in certain regions, as in the reed plains and the U-minh and that owes to the tentative failure of culture in these fertile lands, although toxic. Even in the old provinces, secondary and tertiary management is still lacking, correctly putting the water at the disposition of the rice grower.

The insufficiency of the use of chemical fertilizers is also one of the factors that contributes in lowering the yield above all in the insufficiently managed lands. The plant must be more vigorous to resist the multiple incidents resulting, from one hand from the concentration of the same production in the space and at the time (monoculture) that is revealed in general by an even more intense attack of parasites (of entomologic or mycological origin), on the other hand from the absence of the water mastery.

The necessity of using fertilizers, in particular phosphates, is still greater by the fact that the rices cultivated on our soils have need of much P<sub>2</sub>O<sub>5</sub> to fight against intoxication due to iron and to alumina.

(1) We must point out some routes that failed, such as for example the Quan-Lo canal — Phung-Hiep already mentioned above, and the Rach-Gia route — Ha-Tien that impedes the flowing off of the flood and transforms it sometimes in a catastrophic inundation.

**B Fertilizer formulas for the different rice-growing zones**

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Agrological data permits to trace in South Vietnam different rice-growing zones that are, as it was said above:

- a) Zone situated outside of the delta;
- b) Zone situated in the delta comprising:
  - 1) the floating rice and demi-floating rice zone;
  - 2) the double transplanting zone.
- c) Maritime zone.

Basing ourselves on the results of the fertilizer trials, on the fertilizers applied in the Indochinese Rice Office Stations, and on the agrological and hydraulic conditions, we searched to establish for each rice-growing zone, optimum fertilizer formulas. The "income" factor must be in line for the choice of fertilizer formulas; by this fact nitrogen element, the most expensive, is in general reduced to the indispensable, although it may be, with  $P^{25}$ , one of the limiting factors of the harvest and even though its presence be necessary for the assimilation of other elements.

- a) Zone situated outside of the delta (Thudaumot-Bienhoa-Tay Ninh).

Not one fertilizer trial was undertaken in this zone. At the Phuoc-Tan Station (Bien-Hoa), the adopted fertilizer formula is 70 kg of Gafsa phosphate, that is to say 20 kg of  $P^{25}$  per hectare, and 50 kg of calcium cyanamide, let it be 11 kg of N. The formula employed would seem to suit these soils, sufficiently provided in  $P^{25}$  and rich in  $K^{20}$ . The nitrogen dose, a little weak, can be carried to 15 and even, to 20 kg, either under the form of ammonium sulfate, or under the form of cyanamide.

The effect of the fertilizer on these lands deficient in nitrogen will be accentuated, if the nitrogenous chemical fertilizer is replaced

by a green fertilizer (4 to 5 tons per hectare), or by well conditioned farm manure.

b) Zona situated in the delta of the Mekong:

1) Floating rice and semi-floating rice zone: These lands of recent formation, rich in N, deprived of  $P^{25}$ , must respond advantageously to an application of phosphated fertilizer. However because of the floods, there is reason to use natural phosphates to avoid complete dissipation of fertilizing elements. A massive dose of natural phosphate is thus advised. One will utilize to this effect Gafsa phosphate (28 % of  $P^{25}$ ) 150 to 175 kg per hectare, or phosphate from Tonkin, at the rate of 200 to 250 kg per hectare.

In the rice fields less provided in  $K^{20}$ , one can supply potassium chloride, less expensive than potassium sulfate. Supplying 10 kg of  $K^{20}$  corresponds to 20 kg of potassium chloride.

The spreading of phosphated fertilizer can be done either at the time of the stubble plowing work, after the harvest, or at the moment of the preparation of the lands, before harrowing.

The spreading of potassium fertilizer can take place after harrowing, before seeding.

On the diminished rices, one can advantageously employ natural phosphates in the doses cited above.

2) Double transplanting zone: The Indochinese Rice Office for its Rachgoi station (Cantho) used only phosphated fertilizer (150 to 200 kg of Annam phosphate). Supplying nitrogen is not necessary on these lands, for one thing because of the great solubility of the nitrogenous fertilizers, for another thing because of the richness of the soil in this element. One can, for the lands subjected to a weak liming, add a weak dose of  $K^{20}$  (15 kg per hectare) under the form of potassium sulfate.

c) Maritime zone.

In the old provinces of Cocong, Tanra, Cholon, Giadinh and a part of Mytho, the earth is more worn out than elsewhere. The use of mineral fertilizer becomes a necessity and the Vietnamese rice grower also realizes this fact.

Adding fertilizer must be done not only on the transplanted rice fields, but again on the nurseries.

THE END

The formulas NP and nP (1) are the most interesting from the double point of view of economy and amelioration of yield, according to the results of trials carried out at the Gocong Station (Gocong). In this formula N = 30 kg of nitrogen; P = 40 kg P<sub>2</sub>O<sub>5</sub>; per hectare (1).

For the Travinh and Bentre lands, the obtained results are nearly the same as previously, however the nitrogen dose can be reduced by half because of the more elevated content of the soil in this element. The formula nP is the best one (1)

(1) Here are the conclusions from the fertilizer trial at Gocong undertaken by Mr. Le-Ty, NGUYEN VAN-LE and J. BIARD.

"The only formulas that gave us significant differences in yield are:

FE	ME	NP	NE
N = 15 kg of N	N = 15 kg of N	N = 30 kg of N	N = 30 kg of N
P = 15 kg of P <sub>2</sub> O <sub>5</sub>	P = 15 kg of P <sub>2</sub> O <sub>5</sub>	P = 40 kg of P <sub>2</sub> O <sub>5</sub>	P = 40 kg of P <sub>2</sub> O <sub>5</sub>
K = 15 kg of K <sub>2</sub> O	K = 15 kg of K <sub>2</sub> O	K = 15 kg of K <sub>2</sub> O	K = 15 kg of K <sub>2</sub> O

(1) The conclusions given by TRAN-QUOC-KHANH following a fertilizer trial undertaken at Dalat (Travinh) in 1932-1933-1934 are the following:

"a) Phosphoric acid employed alone, in great or small dose gives in three harvests increasing and important yields. The obtained results show in a tangible way that finely ground natural phosphate (phosphate from Tonkin) has a residual effect that is very clear during several years and that it is logical to conceive that a phosphated fertilizer must be toned down on several successive harvests. The phosphated fertilizer is, despite the sale at a loss of the paddy at this epoch, largely paying in these rice fields;

b) Nitrogen must not be employed alone;

c) Potassium does not play a sharply defined role;

d) The formula producing the greatest increase in harvest is nPo (n = 15 kg of N under the form of ammonium sulfate; P = 50 kg. of P<sub>2</sub>O<sub>5</sub> under the form of natural phosphate, which is the most profitable among the combined fertilizers, all in being the most active".

All of the formulas had last year given significant surpluses".

"The study of the economy of fertilizer permitted this author to conclude thus: the introduction of Moroccan or Annam phosphates in the fertilizer formulas allowed to diminish the returns price of it and to realize for certain ones notably for NP an interesting benefit".

The following table, established with the fertilizer prices and the rate of the paddy in 1934, give the economy of each of the fertilizer formulas:

FORMULES	INCIDENT de culture	VALEUR de l'incident	BENEFICE ou PERTE due à l'INCIDENT		
			Ammonium	Phosphate	Potasse
Fe	6.46	12.42	- 5.83	- 0.31	+ 1.67
Fe	6.46	12.42	- 5.83	- 0.31	+ 1.67
Fe	6.46	12.42	- 5.83	- 0.31	+ 1.67
NP	8.96	16.12	- 1.70	+ 1.72	+ 3.72
NP	11.53	27.86	- 1.70	+ 9.20	+ 11.20
NP	11.79	26.30	- 1.17	+ 2.33	+ 4.33
P-K	12.85	23.70	- 0.85	+ 1.70	+ 2.70

The formula NP is thus the most profitable.

The author of the trial recommended as optimum formulas the following dosages:

25 kg of  $P_2O_5$  under the form of natural phosphate.  
20 kg of N under the form of ammonium sulfate.

The ensemble of these results allows us to recommend for the different provinces of South Vietnam formulas of optima fertilizer. However, if these formulas can be considered as valuable for the majority of rice fields from a province, they must be modified in the case where the fertilizer is made on a particular land, that is to say presenting physical and chemical characteristics other than those that one generally observes in the province.

TABLE I

Formulas of optima fertilizer for the different provinces of South Vietnam.

PROVINCES	FORMULAS de FERTILISERS (in kg elements (active) per hectare)		
	N	$P_2O_5$	$K_2O$
Bartie .....	20	25	
Berie .....	20	20	
Biere .....	15	30	
Binhai .....	20	20	
Chebo .....		30	15
Chenhe .....		30	20
Chien .....	30	30	
Chienh .....	30	30	
Coring .....	30	30	
Hinh .....	30	30	
Lampou .....		30	30
Myhe .....	30	30	
Nahhe .....	20	25	30
Sahe .....		30	30
Tuohang .....	20	25	
Tien .....	30	25	
Tienh .....	20	25	
Tienh .....	20	25	
Tienh .....	15	30	30
Vinh .....		30	15

### Choice of fertilizers

Knowing the fertilizer formulas for the different rice-growing zones, we can proceed to the choice of fertilizer, factor which plays an important role in fertilizing. The sketch that we have given on the nature of the soil permits to trace the general principals in the choice of fertilizer. It is necessary to recommend:

- 1) The use of alkalizing fertilizers, the natural acidity of the soils does not permit the use of acidic fertilizers or fertilizers with acidic tendency.
- 2) The generalization to excess of the politic of phosphated improvements to stop the natural toxicity of tropical soils. These phosphated improvements will be presented under a relatively little assimilable form to prolong their action.
- 3) Beside these 2 points, one must take into account the economic factor that most preoccupies the rice grower. This is the revenue in the use of fertilizers. For that, it is necessary, as much as possible, to choose the least expensive fertilizers, from preference those of local production. In this work, we will occupy ourselves only with 3 fundamental fertilizers putting at the disposition of the plant the N-P-K elements; even though other elements such as manganese (1), magnesium... play a fundamental role also in the nutrition of the plant.

The following table giving the quantity of elements taken up from the soil per ton of paddy per hectare, shows the importance of nitrogen in the nutrition of rice.

Elements taken up from soil per ton of paddy per hectare

Elements taken up from soil per ton of paddy per hectare	GRAINS		Straw		Observations
	Kg	Mg/ha	Kg	Mg/ha	
	Average		Average		
Nitrogen	9.4	15	10.7	10	(X) average after the analyses made at OIR on 55 varieties from South Vietnam.
P <sub>2</sub> O <sub>5</sub>	4.4	4	2.5	2	
K <sub>2</sub> O	2.1	2	5.1	5	
CaO	0.2	0.2	4.1	4	
Mg	1.1	1	1.5	1	

From the point of view of efficacy,  $P_2O_5$  must be cited in first place in the South Vietnamese rice-growing by its role in nutrition, and above all in the desintoxication pointed out earlier. It is the limiting factor of the harvest, while nitrogen is of the least importance, because of the natural richness of the soil in this element. Potassium, although absorbed in massive dosage by rice, possesses a completely secondary role. One does not find it in certain formulas. South Vietnamese lands are well provided in this element. A weak dose of  $K_2O$  however proves itself useful

(1) The trials that I undertook myself at the Indochinese Rice Office show that the greater the Mn dosage, the more the obtained yield is increased. With a dose of 15 kg of  $SO_4Mn$ , the yield is doubled. Notice that  $Mn^{2+}$  is not found in the South Vietnamese soils.

as this element renders the plant more resistant to sicknesses.

#### a) NITROGENOUS FERTILIZERS

The nitrogenous fertilizers are counter indicated in South Vietnam due to their extreme solubility and the ease of their erosion. On the other hand, the rice, in particular rices of the plain, have a marked preference for ammoniac nitrogen, also, only the ammoniacal fertilizers are studied here; certain authors (CHIAPELLI) declare that the nitrated fertilizers sometimes diminish the yield.

##### Ammonium sulfate:

This nitrogenous fertilizer is the most commonly employed in our rice-fields. However it will be able to be replaced advantageously by other non-acidifying fertilizers and a more elevated content in useful elements. Ammonium sulfate having only a content of 20 % in N, is of a non "paying" use above all for the lands estranged from the centers because of the elevated price that occasions its transport.

##### Ammonium chloride:

This fertilizer containing 26 % of useful nitrogen, is still more acidifying than the preceding one. Its use is not equally advisable, although it better supports the charge of burdensome transfers on the long interior distances.

##### Calcium cyanamide:

The nitrogen content of this fertilizer is also weak (22 %), but it contains at the same time 30 to 60 % of lime. We recommend its use for our lands, at least for the future, after the study of better epochs of application and also mode for spreading (1). The lubricated or granulated presentation permits on the other hand to reduce the waste that one can reproach crude and pulverulent cyanamide for. It thus conserves itself better, and can be spread without risk of problems, as much for the cultures as for those that manipulate it.

##### Urea (2):

Urea has a strong content in useful elements (46 %) and must be the choice

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(1) This fertilizer is still an energetic crabicide. The wastes caused by the crabs in South Vietnam justify its use for them alone. It is also a herbicide when one utilizes it in increased dosage; the product is caustic in direct contact with humid vegetative tissues.

nitrogenous fertilizer for the lands situated at great distances.

Ammoniac ( $\text{NH}^2\text{OH}$ ):

Ammoniac represents a fertilizer of the future. Its manufacture will be able to be realized in Vietnam and its effect on yield seems to be superior to that of ammoniac sulfate, according to trials realized at the Indochinese Rice Office. Anhydric ammonium will be less interesting, as it is difficult to conserve and its spreading necessitates a particular material.

A mixed fertilizer, ammonium phosphate is interesting by its nature and its content in useful elements. This fertilizer containing 53 % of soluble  $\text{P}_2\text{O}_5$  and 21 % of N, permits to better solve the problem of transport, thus giving more possibilities of revenue to the fertilizers. Its use in the rice fields must still be put under study, because of its richness in soluble elements; there is place to utilize it in small repeated doses, in proportion as the needs of the plant.

In table I that gives the optima fertilizer formulas for the diverse rice-growing zones of South Vietnam, the nitrogenous fertilizers that we recommend are ammoniac sulfate, whose use is already very generalized, cyanamide and ammoniac, but the last one is still ignored in Indochinese agriculture. However, the results obtained both at the Indochinese Rice Office and abroad already authorize its popularization.

b) — PHOSPHATE FERTILIZERS

The simple or complex superphosphate, despite its strong content in  $\text{P}_2\text{O}_5$  (45 to 50 % for double superphosphate), is counter indicated for the lands of South Vietnam, because of its acidity and its excess solubility that compromises all chance of attaining a substantial revenue from it.

(2) The trials having for goal to compare the different forms of nitrogenous fertilizers show in general, both abroad and in South Vietnam, that ammoniac sulfate is the most efficacious, however in one of the trials realized at Phu-Loc in the course of the 1930-1931 period one declared that the cyanamide form marks a light advantage over sulfate and is 126 with calcium cyanamide, 113.5 with ammoniac sulfate and 118 with urea. The declarations made abroad on the residual effects of ammonium sulfate and of ammoniac ( $\text{NH}^2$ ) show that there is often advantage in changing the form of nitrogenous fertilizer; the use of the same product, above all of ammoniac sulfate, leads often to a noteworthy drop in yield if one stops the addition of fertilizer. The use of nitrogenous fertilizer, to be rational, must thus comprise an alternate deposit of ammoniac sulfate, of cyanamide and urea.



Their  $P^{25}_O$  is liberated too rapidly and is fixed by the iron and alumina salts before having rendered service to the vegetables.

Dicalcium phosphate (1) has strong content in  $P^{25}_O$  (39 to 40 %) gave the best results on our rice fields. However, because of its strong solubility, it is preferable to use it under a roof and in small repeated doses.

The phosphates, in particular the natural phosphates containing an elevated lime content, still plays the role of an improvement and corrects the acidity of our practically decalcified soils. The liming alone does not give most often discounted effects, according to the diverse trials realized at the Indochinese Rice Office (2).

The natural phosphates, as much imported as local, are the most "paying". Their use is simple; one can utilize them in massive dosage like base fertilizer, without fear of a danger of toxicity with regards to the seed beds of the newly transplanted plants, without fear of loss by washing, as  $P^{25}_O$  is powerfully fixed by the soil. There exists in North Vietnam and in Central Vietnam important deposits of natural phosphates; their exportation will put at the disposition of the rice grower of South Vietnam a choice fertilizer from the technical and economical point of view. (3)

(1) Employed comparatively with the local natural phosphate (Annam phosphate) or imported (Algerian phosphate), the dicalcium gives a better growth in yield (fertilizer trials at Phuloc) but its revenue is less.

(2) This negative action of the lime is not yet explained. AURIOL and VANG said: "Why does one not obtain a useful effect with lime? Practiced in high dose, would liming liberate iron or alumina hydrates in "colloidal state with de-flaking of the clay?

Or else, in the processes of desaturation of these soils, the equilibrium between alimentary cations, would it be modified in such a way that a depressive effect would affect the vegetation, even if the absolute content in each of these elements remained sufficient, in which case the liming would not permit to remedy the poor states of the soil, but would risk to aggravate the disequilibrium existing among the cations (CHAMINADE).

(3) One notices on the lands of the Phumy station (Giedinh) that the spreading of natural phosphates modifies the spontaneous flora of the rice fields, it is characterized by the predominance of a Pontederaceae of large edible leaves, the Monochoria vaginalis Presl. (Rau chóc), very sensible plant to the action of herbicides at bottom of 2-4, D.

The action of the natural phosphates however is slow and is not clearly evident until the 2nd rice-growing period (1). There is thus interest in rendering them more soluble and directly assimilable by the plant. Their transformation into superphosphates is not recommended for the reasons given above, while their solubilization by silica, in presence of alkaline carbonates and alkaline earth carbonates to transform them into base phosphates is to be recommended. According to MALYE: "Molten phosphates are the future phosphates for the improvements interesting not only to Indochina but to the majority of tropical soils under hot and humid climates. Their progressive solubility in time makes an improvement in choice of them for the treatment of our acid and toxic soils. Another advantage of the molten phosphates resides in the fact that, to obtain them, it was necessary to incorporate an important part of pure silica. In our acidic lands, silicates of calcium phosphate in molten state decompose themselves in liberating colloidal silica. This in contact with toxic salts from the soil, iron and alumina hydroxydes, finishes by giving secondary and tertiary clays of kaolinite that can only improve the soil and neutralize the toxic action of the dioxides of alumina iron".

### c) — POTASSIUM FERTILIZERS

The two standard commercial forms of potassium fertilizers are potassium chloride and potassium sulfate (2).

These are fertilizers of high content in fertilizing elements (46 % of  $K_2O$  for the first and 48 % for the second), which permits them to support the burdens due to transports. Poorly used these fertilizers can have disastrous effects, as the contributed elements have a tendency to favorize the generalization of an acidity of supplementary exchange; it is necessary to first stop, by phosphated fertilizers, the excess of free Al ions.

(1) One can cite, as an example, the results obtained in one of the later fertilizer trials realized by the Indochinese Rice Office at the Phu-My Station.

Yield obtained in the first period (Favorable atmospheric conditions)

	Témoins Trial	Apatis 50 % de P <sub>2</sub> O <sub>5</sub>	Apatis 100 % de P <sub>2</sub> O <sub>5</sub>	Phosphate d'Al <sub>2</sub> O <sub>3</sub> 50 %	Phosphate d'Al <sub>2</sub> O <sub>3</sub> 100 %
Yield per hec.	1,227 kg	1,294 kg	1,312 kg	1,402 kg	1,412 kg
Surplus on trial	0	67	85	175	85
		Rendement obtenu à la deuxième campagne (Effet résiduel) (Conditions atmosphériques défavorables)			
	Rend. à l'ha... 507	927	1,274	1,177	1,273
	Excéd. sur le témoin	420	767	670	766

Yield obtained at 2nd period

(Unfavorable atmospheric conditions)

The surplus of yield is more marked at the 2nd period than the 1st because of the slow transformation of phosphates, of wearing out of basic reserves of the trial in relation to the preceding period.

Potassium chloride would be preferable to potassium sulfate, because it is much less expensive; however the exchange acidity that provokes the chlorides is higher than that due to the sulfates. Potassium sulfate remains from this fact the only fertilizer to recommend for the rice fields of South Vietnam, at least from the technical point of view.

#### Mode of spreading the fertilizers

As we previously saw, the use of phosphates under the form of natural phosphates is simple. The principal is to spread them in massive proportion as early as possible.

The use of nitrogenous fertilizers is more delicate.

Sulfate of ammonia with great solubility must be spread under a roof. To avoid complete loss, it is good to use it in small repeated doses, say in 3 times:

- 1/3 before transplanting
- 1/3 under roof at tillering
- 1/3 15 days before flowering.

or in 2 times:

- 1/2 before transplanting
- 1/2 15 days before flowering.

One can advantageously utilize cyanamide before transplanting, the complement of nitrogenous fertilizer before flowering being given under form of sulfate of ammonia, as the cyanamide employed as covering fertilizer can burn the leaves. However to avoid these wastes one can operate thus:

a) One mixes the fertilizer with the earth (1 part fertilizer plus 100 parts earth); one puts them all into piles, then waters. Spreading is done when the cyanamide is decomposed, that is to say when the heat from the piles is returned almost to normal.

b) One can spread fertilizer in first mixing it with earth (1 part fertilizer, 6 parts earth) however, one must avoid as much as possible putting the fertilizer in contact with the leaves.

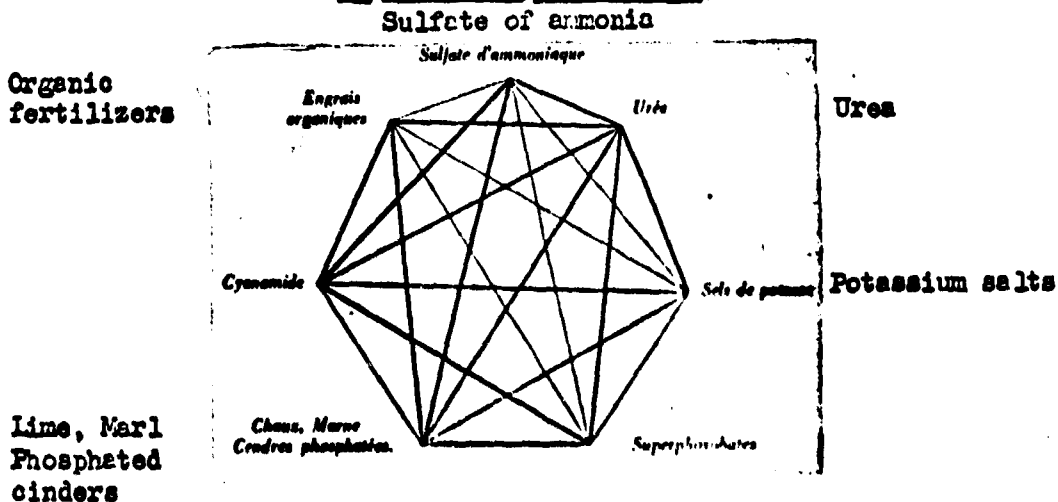
(2) Results from a comparative trial of yield between chloride and potassium sulfate undertaken at Phuloc, show that one can note a slight advantage from the point of view of amelioration of the production in favor of chloride. BLARD concluded "In the choice of potassic salt the rice grower must thus let himself be guided by the question of the price of returns of the unity of  $K_2O$ ".

For the direct seeding rice fields and in the nurseries, the application of the cyanamide must be done in 2 to 3 weeks, before the seed bed in sufficiently humid soil, because of the harmfulness of this fertilizer on the young seedlings in particular.

The mixture of fertilizers that the rice grower himself must carry out on the farm also requires a certain number of precautions. Some fertilizers can react on one another and agglomerate themselves, thus constituting a hard mass necessitating an often impractical fresh grinding again. The association of certain ones among them can give place to losses of fertilizing elements or to a diminishing of activity of these last ones. It is thus for example, that those containing lime: cyanamide, slags, natural phosphates and calcium improvements are susceptible to provoke the shifting of the nitrogen of ammoniac fertilizers or organic fertilizers and to render the phosphoric acid of the superphosphates less soluble.

We give below a table of compatibility and incompatibility of the fertilizers frequently employed in the South Vietnamese rice-growing.

Table of compatibility and of incompatibility of different fertilizers.



One must not mix the fertilizers that occupy the points joined by the thickest lines (→). One mixes immediately before their usage those that are united by the double lines (=). One can always mix the fertilizers that occupy the extremities of the fine lines (→).

C Actual situation of the use  
of mineral fertilizers in South Vietnam

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The use of mineral fertilizer is very restrained in South Vietnam. Thus for an area cultivated in rice field of 2,307,000 hectares in the 1938-39 period, the consumption of fertilizers was only 4,663,500T (importation statistics furnished by the Chamber of Commerce of Saigon), comprises:

Phosphated fertilizers:

Mineral superphosphates.....	2,191, 7T
Phosphated or manufactured fertilizers.....	218, 9
Superphosphate of bone or phosphate precipitated	
from bone.....	0, 2
Diverse.....	48, 9

Nitrogenous fertilizers:

Organic fertilizers (Guano) .....	2. 1
Nitrate of synthetic soda, Calcium cyanamide...	2,201. 7

One can add to this tonnage 40,300 tons of molten natural phosphates from North Vietnam.

One thus sees that in regard to the total cultivated area the quantities of fertilizer employed are insignificant. This weak utilization of the mineral fertilizer is due to several causes:

Ignorance of the rice growers:

The use of mineral fertilizer is limited to the old provinces: Cholon, Tanan, a part of Mythe and of Gocong that is to say in the rice fields using two periods. But even in these zones a good number of rice growers ignore the fundamental notions of the use of fertilizers, the "quantitative" role of the diverse fertilizing elements (N. P. K.) and the laws that govern their use. The choice of fertilizers, in traditional culture, is sometimes not based on the deficiency of the soil in such and such element. Thus if a neighbor or a relative used such and such a fertilizer, with success, the peasant does not hesitate to imitate him, even if his

lands do not need it.

#### Mode of holding lands:

80 % of the lands of South Vietnam are exploited by the farmers. The farm contract is most often established only for one year, this insecurity of the "ta-dien" situation does not encourage bringing ameliorations (management — fertilizer) as one is not certain of ulteriorly profiting from it. The land proprietor, more learned in general, takes no interest however in his lands and talks to the farmers in terms of financial relations only.

#### Expensiveness of fertilizing elements:

But the principle factor that limits the use of fertilizers is disputably the expensiveness of fertilizing elements. One attributes failure all attempts to popularize the use of mineral fertilizer. Also, numerous studies were already made by the Indochinese Rice Office in view of determining the question of revenue, starting from the best fertilizer formulas. The results obtained show that the use of fertilizers is not profitable, even though the amelioration of the yield may be substantial (1).

(1) Thus in a semi-industrial trial of natural phosphates at Soctrang, the calculation of revenue gave for a fertilizer of 200 kg of natural phosphates the following figures:

Increase in yield.....	41 gia 75 (1 gia = 22 kg 400)
Raw benefit.....	$10\$25 \times 41.75 = 10\$44$
Cost of fertilizer.....	8\$88
(without transport cost from Saigon-Soctrang and spreading cost)	
Net benefit.....	1\$56
equivalent to 6 gia paddy.	

It is necessary to add to this figure the net benefit originating from residual effects, the remaining influence from this fertilizer can last 3 years. One remarks thus in the trial on the use of natural phosphates pointed out in reference 1 on page 23 that the surplus yield obtained at the 2nd period is higher than that registered at the first one. Be that as it may, the use of fertilizer is not sufficiently profitable to encourage the Ta-dien to employ it.

TABLE GIVING THE PRICE IN PIASTRES I. C. OF THE UNITY OF FERTILIZING ELEMENTS AT SAIGON AND IN FRANCE (the franc is evaluated in piastres on the basis of 10 fr. = 1\$ I. C. course 1939)

Eléments: Unité = 1 kg	France	Indochine	Origine
Azote (N) .....	0.65	7.5 à 7.9	Sulfate d'ammoniaque
Acide phosphorique (P <sub>2</sub> O <sub>5</sub> ) .....	0.14	2.23	Hyperphosphate
Potasse (K <sub>2</sub> O) .....	0.25	2.50	Chlorure de potasse
Acide phosphorique (P <sub>2</sub> O <sub>5</sub> ) .....	0.1	1.70	Phosphate naturel

Potassium chloride

The chemical fertilizers were thus more expensive in Indo China than in France and this disadvantage is still accentuated, for the Vietnamese rice grower, by the fact that rice is a poor product.

This expensiveness of fertilizer still clearly appears if one compares the price of a kilo of active element of fertilizer in relation to wheat in France and rice in South Vietnam:

Expressed in kilo

	Rapport en kilo		Observations
	de paddy	de blé	
Kilo d'azote d'ammoniacal	13	3	Les prix sont basés sur ceux pratiqués en 1939
P <sub>2</sub> O <sub>5</sub> de l'hyperphosphate	1.7	0.6	
K <sub>2</sub> O du chlorure de potasse	4	0.5	

The prices are based on those practiced in 1939

Actually (1952), the price of fertilizer is also elevated, a ton of sulfate of ammonium sells at 2,290\$00 (1) either 11\$50 per kilo of nitrogen corresponding to 10 kilog of paddy. A ton of phosphate from Algeria at 977\$00, or 3\$50 the kilog of P<sub>2</sub>O<sub>5</sub>.

The revenue factor is certainly the limiting factor for the use of fertilizers; the use of mineral fertilizer will be intensified only when the value of the useful elements of fertilizers is lowered.

(1) Delivered to the stor at Saigon.

## of mineral fertilizers

With the gratis distribution of fertilizer (1), such as they do lately, the question of revenue is no longer valid. However the results obtained are not those that one is in the right to discount because of a non-rational use of fertilizers in traditional rice-growing. It is necessary to put at the disposition of the rice grower optimum fertilizer formulas.

On the basis of the previously recommended formulas for the diverse rice-growing zones, it is possible to calculate, province by province, the quantity of fertilizer necessary for the rice fields.

## TABLE II

Tonnage of fertilizing elements used in South Vietnam

[illegible]

(1) This gratis distribution of fertilizer is a temporary measure destined to attenuate the deficit of production (reduction of the cultivated area because of problems). It risks perhaps to habituate the rice grower to the abnormally elevated beneficiary margin and realized imitation from gratis fertilizers and to lead him to find without interest the much more reduced benefit, but normal, that will procure the use of bought fertilizers.



The consumption of fertilizers would be raised to a tonnage of: 32,000T of N, 78,000T of  $P_2O_5$  and 7,000T of  $K_2O$ .

Nitrogen will be used under the form of calcium cyanamide; or half under the form of sulfate of ammonium. It will be necessary thus to furnish to the South Vietnamese rice grower:

76,500 tons of calcium cyanamide and  
78,000 tons of sulfate of ammonium.

Phosphoric acid will be furnished for the 2/3 by natural phosphate from North Vietnam (38 %  $P_2O_5$  total), it remaining under the form of dicalcium phosphate, that is to say about:

137,000 tons of phosphate from North Vietnam.

65,000 tons of dicalcium phosphate.

Potassium will be employed under the form of potassium chloride, despite the inconveniences cited further up. It is chosen for its price that is half of that of potassium sulfate. The tonnage of utilized fertilizer will be in the order of

15,000 tons of potassium chloride.

#### Conditions of intensification in the use of fertilizers

The revenue factor of which we have previously spoken of is the essential factor of intensification in the use of fertilizers. As long as the fertilizer will remain slightly paying, all popularization enterprise of propaganda will be destined for failure. The agriculturer is like the manufacturer, it is not only necessary for him to produce more, but to produce more and at a less expensive price.

DAVIS, former director of the Indochinese Rice Office, in a meeting with the Council of Administration of this establishment said in effect: "One should not allow himself to have illusions on the economic possibilities of mineral fertilizer if the actual course of fertilizers and of the paddy maintain themselves. The development of the use of fertilizers will only come about if we find less costly sources of fertilizing elements, above all on the side of nitrogen."

The natural resources of the country permit in effect to put at the disposition of the agriculturers fertilizers at a lower price with a politics of a more pushed industrialization of the country".

The industrialization plan previewed in fact the manufacture of ammonia from atmospheric nitrogen, the creation of factories that made carbide and calcium. This last one, being the departure point of numerous synthesis industries, such as the manufacturing of solvents (trichlorethylene, carbon tetrachloride) and acetic acid that one can transform easily and economically into cyanamide.

The important deposits of natural phosphates (1) and the possibilities of transforming them under more soluble forms will put at the disposition of the peasant fertilizers whose use conditions the production in South Vietnamese rice-growing.

For the potassium fertilizers, of minor importance, one can replace them by vegetal cinders (25 to 50 % of  $K_2O$ ), straw cinders (13 % of  $K_2O$ ), or mother waters of salt marsh (9 % of  $K_2O$ ). The remaining must be imported.

For the nitrogenous fertilizers, the Indochinese Rice Office thought of replacing them by green fertilizers that, beside the nitrogen deposit and the enrichment of the soil in humus, have certain other advantages that are the following:

- 1) augmentation of the freshness of dry lands and loosening of compacted earth.
- 2) put at the disposition of the culture of rice phosphated and potassic combinations easy to use.
- 3) reduction of nitrogen losses by washing as the legumes accumulate the nitrates contained in the soil and utilize them in proportion with their formation. Fertilizer trials were undertaken to this effect at the Cantho Station by BIARD. The study was performed on fifty-six varieties of legumes, imported either from the north or from the center of Vietnam, or even abroad, as the Astragalus sinensis from Japan. The behavior of these legumes on our lands, somewhat particular because of their toxicity, was little satisfactory, which bring BIARD to conclude that there is more of an interest to research and to cultivate these spontaneous legumes in rice fields as the "cay con bét" (Casualtia type) that had to be interesting by its hardiness and its great production of green material. The Dien-dien (Aeschynomene annamita Retz) could also be tried because of its resistance to alumed lands, however its production of green material is weak. In terms of imported legume, one could study Tephrosia purpurea whose culture could be done during the dry season because of its small water requirement. In India, the grains of Tephrosia purpurea are seeded before the harvest of the paddy and its vegetation takes place during the four or five months of the dry season.

Manure, in insufficient quantity, because of the minor importance of rearing, can be replaced by artificial manure prepared from "luc binh" (*Eichhornia crassipes*) that one finds in abundance in South Vietnam. The destruction of these spontaneous vegetation is on the other hand necessary as it often hinders the overflowing of the water in the canals the the course of the water, its presence is also perceived by a reduction of the pisciculture population.

Thus, with the green fertilizers cultivated "in situ" on well managed rice fields or artificial manure prepared from "luc binh", the rice grower has at his disposal nitrogenous fertilizing elements that are inexpensive that would allow him to reduce his purchases of mineral fertilizers.

The utilization of organic manure reacts favorably on the yield; the obtained results at the Phu-Loc Station (Soctrang) show in fact that "four tons of green materials, incorporated in the soil in two years produce the same effect as 35 kilog of mineral nitrogen".

The economic production of green fertilizers, however, remains an arduous problem for the lands of South Vietnam; a satisfactory solution would be obtained only if one had at his disposal hardy varieties and a strong production of green material.

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The encouragement to local production of fertilizers and the help of the Government to rice growers must aim at the same goal: the kilo of the active element in the fertilizer expressed in kilog of paddy must

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(1) The principle deposits of natural phosphates actually known in Indo China are:

North Vietnam. — Grottoes in the massive Kaikin on the border of the macadamized road of Phu lang thuong at Lang son; grottoes in the region of Nacham, near the Chinese frontier; serie of small veins of Lang lut, in the North of Thai Nguyen; deposit of Yen bai and of Luc an chau, on the border of the Red River and of the Song Chay.

Central Vietnam. — Grottoes of Thanh hoa on the border of Song Ma and of Song Chau; grottoes and fissures in the region of Vinh on the border of Song Ca; serie of small veins in the region of Dong hoi.

Cambodia. — Serie of small veins in the region of Tuk Neas (province of Kampot) and to the West of Battambang.

must be at least of the same order as that of fertilizer in relationship with wheat in France, that is to say:

1 kilog of N equivalent to 3 kilog of paddy.					
1	—	$P_2O_5$	—	0.6	—
1	—	$K_2O$	—	0.5	—

The rational utilization of fertilizers in traditional culture requires of the agriculturer knowledge of the principals, or at least elementary ones, of manure, to know the role of the N. P. K., the maladies that result from a poor nutrition. The meager results obtained recently in South Vietnam with the distribution gratis of fertilizer, show the importance of agricultural popularization in the practice of manure.

Because of the expensiveness of fertilizers, the technical services and the research centers must follow their studies in view of utilizing to the maximum the fertilizing elements incorporated in the soil, in reducing to a minimum the losses by washing or by transformation into non-assimilable products.

Thus, "the transformation of cyanamide into usable ammonium ions for the plant must be studied in the case of high lands and rice field lands, principally in taking into account conditions that can influence this transformation: humidity, acidity of the soil, release of  $CO_2$ . From this study, it will then be possible to deduce from the practical point of view, the spreading epoch and the time that the fertilizing element begins to react, the direct action of the cyanamide and of its transformation products on the plantation cultures and in particular on the radicular system" (CASTAGNOL).

And it is also part of the goal to best utilize the fertilizings that the Physiology laboratory proposes to study certain procedures of use of fertilizers (1) that have given the best results abroad.

The study of "fertilizer placing" (localization of the manure) is in progress. This manure method which consists in placing the fertilizing elements in well defined positions, in relation with the seed beds, allows not only to reduce the dose of applied fertilizer, but it facilitates again the separation of the vegetation, the fertilizer being placed near the roots, it restrains losses from the solubility of  $P_2O_5$  and of  $K_2O$ , the contact of fertilizer with the soil being relatively limited.

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(1) Extract from the work program of the Physiology laboratory of the Indochinese Rice Office.

The plowing into the ground of sulfate of ammoniac dry and in depth (Fukasee) recommended by the Japanese scientists was tried. It also reduces the losses of fertilizing elements incorporated in the soil, in diminishing the loss of ammoniacal nitrogen by oxydation and reduction.

The treatment of seed beds by nutritive solutions recommended by the Cuttack Institute (India) will be able under little to be popularized. If the ameliorization obtained by this method is not comparable to that obtained with a copious manure, it is however interesting because of the small doses of fertilizing elements employed. Certain products of local origin containing hormones, like coconut milk, were employed with success.

The treatment of chemical products with a hormone base (1) will be attempted in the course of the year 1952.

One should notice however that the treatment of the seed beds, either by nutritive solutions or by hormones, gives the best results only on a well manured earth. On earth without fertilizer, the amelioration of yield will be achieved at the expense of a more rapid exhaustion of the soil: the more vigorous plant demands more nutritive elements to develop itself.

The study of organic manure is also foreseen; it affects the choice of green fertilizers, and the plowing into the ground of shredded straw in the lands of the rice fields.

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Although one must follow the research in view of being able to better utilize all of the elements that play a role in our rice-growing production, the acquired scientific knowledge already allows the rice grower to augment his yield by the rational utilization of fertilizers.

However, he can do it only with the aid of a technical and financial assistance.

By technical assistance we wish to speak of services rendered by the bureaus of consultation and of agricultural popularization. It is part of these bureaus duty to make the peasants benefit from modern technical knowledge, to bring to them all of the necessary information and to adapt them to their own problems. The most up to date rice grower informed of the results of research equally has need of counseling and of supplementary

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(1) In Japan, the use of sodium salt of naphtalene-acetic acid gave an amelioration of 5 % in relation to the control experiment.

aid to put these results into practice. The work of agricultural popularization can be carried out in South Vietnam by agents of the Agricultural services aided by local guides chosen among the rice growers having the most open minds and more developed social sense than the others (the Huong-kien-dien). The direction of these agents in a province must be confided to an agronomist having general knowledge of the soils and of the fertilizers. These agronomists must be able, in their turn, to consult the soil specialists on the most complex questions.

We have just briefly underlined the importance of the popularization, such as it comprised the Indochinese Rice Office since its creation (1). The results obtained are not however those that one is in the right to discount because of the particularly routine and conservative character of our peasants. A firmer, more directed, agricultural politic, based on the obligatory use of fertilizers and selected seed beds could facilitate the work of the popularization services.

By economic assistance, we wish to speak of the subsidy accorded to the rice growers for the purchase of fertilizers, in order to maintain a favorable equilibrium between their prices and those of agricultural products. This subsidy takes on different forms: prime to the merchants of fertilizer to allow them to reduce the selling prices, organization of far less burdensome methods of transport for the fertilizers, sale on credit without interest or a very small rate until harvest. The value of the supplementary production would permit the rice grower to cover the purchasing costs of the fertilizings.

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(1) In Vietnam where agriculture is still scarcely evolved and is practiced according to ancestral methods, popularization must be still more important than elsewhere. However the personnel charged with this work is very reduced; one agent for 3,000 km<sup>2</sup>, while in Japan one can count one popularization technician per 8 km<sup>2</sup>.

### CONCLUSIONS

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The ensemble of measures envisaged above permits to resolve the problem of fertilizers.

The researches recommended that are made in taking into account the data which is most recent of the chemistry of the soil and of the physiology of rice permitted to further define the fertilizer formulas to adopt.

Industrialization of the country will place at the disposition of the rice growers not only fertilizers at a low price, but will furnish new openings to the local men in the chemical industries. Furthermore it will lead to an appreciable importation of foreign bills due to the growth in exportation of rice.

These measures must be completed however by a certain number of governmental reforms. Thus the relations between "ta dien" and proprietors must be regulated in fixing in a rational manner the part of each in the revenue, in fixing the minimum duration of the farm contract so that the farmer can profit from the residual effects from phosphated fertilizers.

The importance of rice-growing production for South Vietnam justifies the application of these diverse measures. It would permit an annual surplus of production from 50,000 to 100,000 tons of paddy (growth from 25 to 50 % of production) that can be evaluated at 140,000,000\$IC.

Saigon, March 31, 1952.

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